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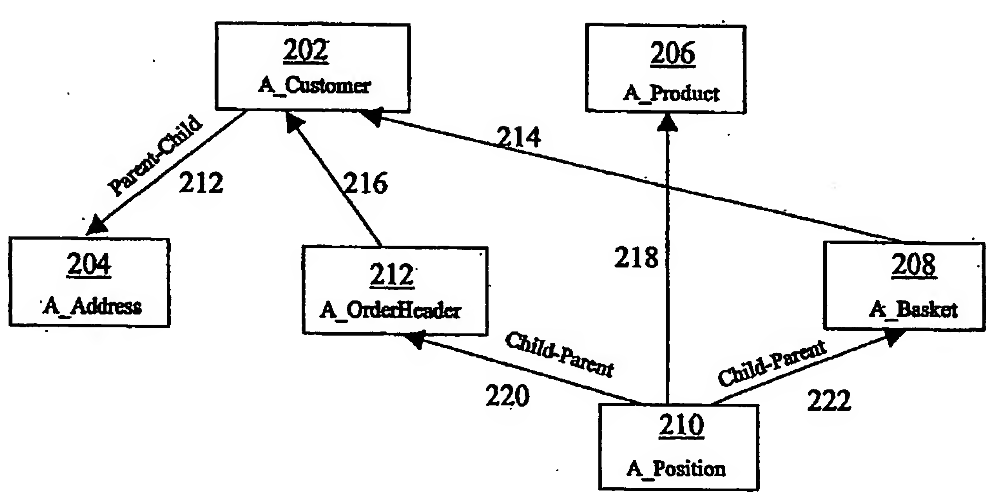

(57) Abstract: Methods and apparatus, including computer program products, for using a meta model for an enterprise service architecture. The meta model includes a first class to represent data organization in a back end data store. The first class includes a data type identifier attribute to permit meta data to identify a data type. The meta model also includes a second class associated with the first class. The second class includes a field identifier attribute to permit meta data to identify fields for a particular data type. The meta model also includes a third class associated with the first class. The third class includes an action identifier attribute to permit meta data to identify an action. In some examples, there is a service provider identifier to permit meta data to identify a service provider class that can effect the action.

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META MODEL FOR AN ENTERPRISE SERVICE ARCHITECTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application incorporates by reference the content of U.S. Provisional Application No. 60/489,573, filed July 22, 2003, entitled ENTERPRISE SERVICES FRAMEWORK TECHNOLOGIES and U.S. Utility Application No. 10/747,033, filed on December 23, 2003, entitled META MODEL FOR AN ENTERPRISE SERVICE ARCHITECTURE.

BACKGROUND

The present invention relates to data processing by digital computer, and more particularly to a meta model for an enterprise service architecture.

Large scale business software applications are sometimes categorized in terms of a "front end component" that includes a graphical user interface (GUI) to present data to users and accept data entry from users. Such front end components are customized for specific customers. Another component of such software applications is sometimes referred to as a "back end component" that stores business data and processes the business data according to business logic. The back end component retrieves, generates, and maintains the business data. The back end component is usually responsible for the consistency and correctness of the data. The back end component also can store relationships between the various data. In a typical business software application, the front end component includes application code to display and aggregate data of the back end and provides help to generate requests to the back end for update operations.

The data of the back end can be represented using relational database terminology. In relational database terminology, an *entity* is a record and an *entity type* is a set of entities with common attributes to which a unique name and a unique description are assigned. Typically, a database has multiple two dimensional tables where each table represents an entity type and each row in each table represents an entity. An *attribute* is a description of a characteristic of an entity or entity type. Typically, an attribute is specified in a field or a column in a database table. Entity types can also have

relationships that enable linking one or more entities of an entity type to other entities of another entity type. This linking can be done using foreign keys by having one or more fields in one table pointing to a primary key of a second table. This enables traversing from a set of entities in one table to related entities in another table.

SUMMARY OF THE INVENTION

The present invention provides methods and apparatus, including computer program products, for using a meta model for an enterprise service architecture. In general, in one aspect, there is a computer program product, tangibly embodied in an information carrier, for using a meta model for an enterprise service architecture. The computer program product is operable to cause data processing apparatus to interact with data conforming to a data model. The data model includes a first class, a second class, and a third class. The first class represents data organization in a back end data store. The first class includes a data type identifier attribute to permit meta data to identify a data type. The second class is associated with the first class. The second class includes a field identifier attribute to permit meta data to identify fields for a particular data type. The third class is also associated with the first class. The third class includes an action identifier attribute to permit meta data to identify an action. There is also a service provider identifier. The service provider identifier permits meta data to identify a service provider class that can effect the action.

Other examples can include one or more of the following advantageous features. The first class can include an association to a fourth class that represents a structure of fields included in the particular data type. The data model can include a fourth class representing a service module that combines a group of data types. The data model can include a fifth class associated with the fourth class. In such examples, the fifth class can include a query identifier attribute to permit meta data to identify a query associated with the service module. The first class can include a key identifier to represent a key for the data type.

In another aspect, there is a computer program product, tangibly embodied in an information carrier, for using a meta model for an enterprise service architecture. The computer program product is operable to cause data processing apparatus to interact with data conforming to a data model. The data model includes an aspect class, a structure class, an aspect action class, and a relation class. The aspect class includes a key identifier. The aspect class represents data types in a back end data store. The structure class is associated with the aspect class. The structure class represents structures included in the data types of the aspect class. The structure class includes an aggregation of a field class. The aspect action class is also associated with the aspect class. The aspect action class represents actions associated with the data types of the aspect class. The relation class is also associated with the aspect class. The relation class represents a relation between instances of the aspect class.

Other examples can include one or more of the following advantageous features. The aspect class can have an association to a service provider class. The data model can include a service module class associated with the aspect class. The data model can include a query class associated with the service module class. The association between the query class and the service module class can be an aggregation. The association between the query class and the service module class can be an aggregation. The association between the aspect class and the relation class can be an aggregation. The aggregation can be by a source aspect. The association between the aspect class and the aspect action class can be an aggregation.

In another aspect, there is a method for storing meta data conforming to a meta model in a repository used by an enterprise service architecture. The method includes defining a first meta data element that is associated with an aspect class representing a data type in a back end data store. The method also includes defining a second meta data element that is associated with a field class representing an attribute of the data type in the back end data store. The method also includes defining a third meta data element associated with an action class representing an action associated with the data type in the back end data store. The method also includes defining an identifier that identifies a

service provider class to effect the action defined by the third meta data element. The method also includes storing the meta data elements and the identifier in the repository.

Other examples can include one or more of the following advantageous features. The method can include verifying the first, second, and third meta data elements conform to the aspect class, the field class, and the action class, respectively. The method can include querying the repository to access the meta data elements to determine organization of data in the back end data store.

In another aspect, there is a system using a meta model for an enterprise service architecture. The system includes a repository that includes data conforming to a data model. The data model includes an aspect class, a structure class, an aspect action class, and a relation class. The aspect class includes a key identifier. The aspect class represents data types in a back end data store. The structure class is associated with the aspect class. The structure class represents structures included in the data types of the aspect class. The structure class includes an aggregation of a field class. The aspect action class is also associated with the aspect class. The aspect action class represents actions associated with the data types of the aspect class. The relation class is also associated with the aspect class. The relation class represents a relation between instances of the aspect class.

Other examples can include one or more of the following advantageous features. The aspect class can have an association to a service provider class. The data model can include a service module class associated with the aspect class. The data model can include a query class associated with the service module class. The association between the query class and the service module class can be an aggregation. The association between the query class and the service module class can be an aggregation. The association between the aspect class and the relation class can be an aggregation. The aggregation can be by a source aspect. The association between the aspect class and the aspect action class can be an aggregation.

The invention can be implemented to realize one or more of the following advantages. The meta model for an enterprise service architecture can provide a way to model both a description of the data and their relations and the functionality of the

business logic in the back end. The meta model can provide a separation between the back end and the front end and also provide the necessary interfaces for the front end to interact with data in the back end. The meta model can provide platform independence. The meta model can provide scalability in local and remote scenarios. The meta model can enable extensibility for industry specific and customer specific solutions. The meta model can provide support for open Web-based standards.

The details of one or more implementations of the invention are set forth in the accompanying drawings and the description below. Further features, embodiments, and advantages of the invention will become apparent from the description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an example logical representation of a business software application.

FIG. 2 is a view of a network configuration for a business software application.

FIG. 3 is a block diagram of the business software application of FIG. 1.

FIG. 4 is a Unified Modeling Language (UML) representation of a structure of a meta model repository.

FIG. 5 is a flow diagram of a business process.

FIG. 6 is a diagram showing relations between different aspects for a business software application.

DETAILED DESCRIPTION

FIG. 1 illustrates an overview logical representation of a business software architecture 2, which includes a client 3, a separation layer 5, a repository 7 and backend data 9 and 9'. Client 3 provides a user interface (UI) that enables a user to interact with the backend data 9 and/or 9'. Backend data 9 and 9' can be associated with different backend applications and/or can be arranged and formatted differently from each other. Separation layer 5 separates the front end user interface provided by client 3 from the

back end data **9** and **9'**. This separation enables client **3** to interact with backend data **9** and **9'** in a consistent and similar manner, regardless of the formatting or application-associated differences between backend data **9** and **9'**. In other words, separation layer **5** provides a canonical interface to backend data **9** and **9'** so that client **3** is configured to interact with separation layer **5** and only needs to be updated if separation layer **5** changes. Changes to backend data **9** and **9'** do not necessitate an update to client **3**. Further, separation layer **5** is scalable and configured to handle changes and growth to backend data **9** and **9'** and any other disparate backend data and backend services that are further connected to separation layer **5**.

As described in more detail below, separation layer **5** is based on a meta model that defines how backend data (e.g., **9** and **9'**) are represented in separation layer **5**. Meta data is stored in repository **7** that describes how the backend data **9** and **9'** fit into the meta model representation. Client **3** interacts with backend data **9** and **9'** using a generic command set defined by separation layer **5**. As described in more detail below, separation layer **5** accesses service providers that perform the generic commands from client **3**, using the meta data in repository **7**, to effect the requested manipulation of backend data **9** and **9'**. The service providers are configurable so that different service providers can be used for different backend data **9** and **9'**. Separation layer **5** includes an interface (e.g., a service manager) that hides the characteristics of the corresponding backend data **9** and **9'** and also the granularity and distribution of the implementation (i.e., the service providers).

FIG. 2 illustrates an example implementation of the business software architecture **2**. As shown in FIG. 2, the business software architecture **2** includes a first computer **4** and a second computer **6**. The computers **4** and **6** each can include a processor, a random access memory (RAM), a program memory (for example, a writable read-only memory (ROM) such as a flash ROM), a hard drive controller, a video controller, and an input/output (I/O) controller coupled by a processor (CPU) bus. The computers **4** and **6** can be preprogrammed, in ROM, for example, or the computers **4, 6** can be programmed (and reprogrammed) by loading a program from another source (for example, from a floppy disk, a CD-ROM, or another computer) into a RAM for execution by the

processor. The hard drive controller is coupled to a hard disk suitable for storing executable computer programs, including programs embodying the present invention, and data. The I/O controller is coupled by an I/O bus to an I/O interface. The I/O interface receives and transmits data in analog or digital form over communication links, e.g., a serial link, local area network, wireless link, or parallel link. Also coupled to the I/O bus are a display and a keyboard. Alternatively, separate connections (separate buses) can be used for the I/O interface, display, and keyboard.

A network **20** connects computers **4** and **6**. The network **20** is any form or medium of digital data communication, e.g., a communication network. Examples of communication network **20** include a local area network ("LAN") and a wide area network ("WAN"), e.g., the Internet.

Computer **4** executes instructions of a front end application program **12**. Application program **12** represents a front end component of the business software architecture **2**. Service manager **16**, running on computer **6**, is a service layer between the front end application program **12** and a set of back end service providers **26**. Service manager **16** provides a service interface to front end application program **12** to enable indirect interaction with the set of back end service providers **26** running on computer **6**. This service interface allows for a partial separation of software development for front end application program **12** and the set of back end service providers **26**.

Computer **6** includes a data storage device **22** that stores a back end database **24** containing data that can be used by the set of back end service providers **26**. Computer **6** also includes a data storage device **8** containing an information repository **18** that defines and describes the services provided by the set of back end service providers **26**. The meta data in repository **18** is organized according to a meta model.

In general, a meta model is a collection of "concepts" that are the vocabulary with which a certain domain can be described. Meta models typically are built according to a strict rule set, which in most cases is derived from entity-relationship-attribute or object-oriented modeling. The front end application program **12** can access (and interpret according to the strict rule set) the contents of repository **18** via the service manager **16**. These services support the functionality of application program **12** and include retrieving

and reading data in addition to modifying stored data. The service providers **26** can access or modify stored data in backend database **24** to provide services to front end application program **12**. To provide the services, the set of back end service providers **26**, upon request from the front end application program **12**, either access or modify stored data in backend database **24** or calculate new data.

The repository **18** defines a syntax for requesting services provided by the set of back end service providers **26** and semantically describes the services. As front end application program **12** executes, front end application program 12 can use this syntax and semantic description from the repository **18** (accessed through the service manager **16**) to determine what services front end application program **12** can use to meet its requirements. This syntax and semantic description for stored or computed backend data can be referred to as "meta data". This stored or computed backend data is conceptually organized using object-oriented terminology in terms of *business objects*, where each business object is an instance of a class or data entity type. In one example, a class of business objects refers to a relational database table where each row of data in the table represents the data for a particular business object. In this example, each field in the table represents an attribute of the business object class. In another example, there is a class of business objects that partially refers to a relational database table such that some of the fields in the table represent attributes of the business object class and other fields are computed upon request.

In the business software architecture **2**, services provided to front end application program **12** are focused on data (i.e., data-centric) so the description of these services in repository **18** is also data-centric. Thus, the meta data in repository **18** is structured around representations of classes of these business objects. This meta data includes *aspects,* or descriptions of these representations of business object classes, and descriptions of available operations on aspects such as select, insert, update, delete, select by relation, and update fields that are provided by service providers **26**. Each description of these aspects includes data attributes as well as actions that can be requested to be executed by the set of backend service providers **26** on instances of these aspects.

Classifications of data, relations between data classes, prebuilt queries for accessing data, and other descriptions of data provided by the set of backend service providers **26** are represented by repository **18**. This representation, or meta data, of data (e.g., stored in backend database **24**) provided by the set of backend service providers **26** describes different abstract types or classes of data in backend database **24** and how different data classes relate to each other. Objects are instances of these different abstract types. Meta data is information about data rather than content of the data. The meta data also defines a set of pre-built queries that can be executed on the data in database **24**.

The semantic description in repository **18** can enable front end application program **12** to determine which services to request from service manager **16**. These services often take the form of requesting data to display. Front end application program **12** reads the meta data in repository **18** and can flexibly request data organized in different ways that are specified by the meta data. For example, two service managers **16** with two different repositories **18** handle services that determine prices of books for companies A and B. For A and B, book prices are represented by different aspects with different data fields. Front end application program **12** reads A's repository **18** to obtain descriptions of data (including a price) concerning a particular book from A's service providers **26**. Front end application program **12** reads B's repository **18** to obtain descriptions of data (including a price) concerning a particular book from B's service providers **26**. Front end application program **12** is able to request and display the information from A's service provider **26** and the information organized differently from B's service provider **26** to present the book price information to a user.

For requesting the services described by the semantic description in repository **18**, service manager **16** provides a canonical interface for services on the business objects in the backend. This canonical interface includes a set of standard operations on the business objects. Such standard operations on the business objects include select, insert, update, delete, select by relation, and update fields. These standard operations are intended to be easy to understand and use. The usage of these standard operations is understood through the strict rule set of the meta model of the repository **18**. Furthermore, the repository **18** also includes documented modeling of the side effects of

the usage of the operations. The side effects for an operation model which stored business objects are affected by executing the method. For example, "delete" usually has a side effect on other stored business objects related to the deleted object. Other standard operations perform more specialized tasks and support functionality for transactions between front end application program **12** and service manager **16** (e.g., a lock operation).

The canonical interface provided by the service manager **16** also includes specialized actions that are defined for specific classes of business objects and queries that can be defined for clusters of classes of business objects. The clusters are modeled as service modules (described in more detail below) in the meta data. These actions and queries are also defined in the meta data of the repository **18**.

During execution, front end application program **12** issues service requests to service manager **16**, service manager **16** checks the requests for consistency with the meta data in repository **18**, and then the service manager **16** passes the requests to back end service providers **26** according to the meta data in the repository database **18**. The manner of implementing the set of back end service providers **26** and data in database **24** is independent of application **12**, with back end service providers **26** and data in database **24** conforming to the definitions and descriptions of the meta data in the repository **18**. Database **24** can be a relational database. However, database **24** can be modified to use a different mode of data organization other than a relational database and front end application program **12** does not need to be modified if back end service providers **26** and data in database **24** still conform to the meta data in the repository **18**. One such different mode of data organization for database **24** can be an object-oriented database.

Front end application program **12** provides user interfaces displayed on monitor **10**. Front end application program **12** provides application code to display and aggregate the data received from the set of backend service providers **26**. Front end application program **12** generates requests, via service manager **16**, to the set of backend service providers **26** for standard operations such as select, insert, update, delete, and execute in addition to more specialized operations. Front end application program **12** is interaction-

centric, focused on aggregating data of the back end service providers **26** and combining interactive steps into a flow of screens and syndicated screen elements.

Front end application program **12** contains screen-flow logic of User Interface (UI) oriented applications and front end application program **12** binds a UI to the meta data in repository **18**. Front end application program **12** can be indirectly bound to a specific set of backend services by back end service providers **26** via descriptions of the services in the metadata of the repository **18**. Front end application program **12** can also be formed from various generic interaction-centric front-end layers that are only bound by configuration to a highly standardized service layer by service manager **16** serving as an intermediary to back end service providers **26**.

In some implementations, a service manager proxy **14** gives the front end application program **12** a buffered access to a service interface provided by service manager **16**. Service manager proxy **14** is a server on computer **4** that acts as an intermediary between the front end application program **12** and the service manager **16** so that the business software architecture **2** can ensure security, administrative control, and caching service. The service manager **16** offers a queuing functionality, which is used by the front end application program **12** to bundle several service requests or commands (resulting in service methods) into a single service method queue in order to save round trips. Service manager proxy **14** allows front end application program **12** and service manager **16** to be separated onto different computers **4, 6**. Furthermore, use of service manager proxy 14 can allow service manager **16** and the set of backend service providers **26** to be distributed over multiple computers.

In one example, the service manager proxy **14** communicates with service manager **16** using SOAP (Simple Object Access Protocol) messages via network **20**. SOAP is a way for a program running in one kind of operating system (such as a Windows® XP Operating system available from Microsoft Corporation of Redmond, WA) to communicate with a program in the same or another kind of an operating system (such as Linux) by using the World Wide Web's Hypertext Transfer Protocol (HTTP) and Extensible Markup Language (XML) as mechanisms for information exchange. Since Web protocols are installed and available for use by all major operating system platforms,

HTTP and XML provide a solution to a problem of how programs running under different operating systems in a network can communicate with each other. SOAP specifies exactly how to encode an HTTP header and an XML file so that a program in one computer can call and pass information to a program in another computer. SOAP also specifies how the called program can return a response.

As shown in FIG. 3, the service manager **16** provides an interface (defined by the meta data in repository **18**) to front end application program **12** that hides the characteristics of the corresponding back end service providers from the set of backend service providers **26** and data in database **24**. Front end application **12** uses this interface to retrieve data from backend database 24 to display in graphical user interface (GUI) **28** for interaction with a user.

The service manager **16** provides the interface to front end application program **12** by receiving and executing requests from front end application program **12** to backend service providers **26**. After each receipt of a request by the service manager **16**, the service manager **16** delegates the request to one or more service providers **30, 32, 34, 40, 42, 44**, and **46**. Service provider **30** is an instance of a software class repository service provider. Service providers **32, 34, 40, 42, 44**, and **46** represent instances of software classes such as query service provider class (**32**), aspect service provider class (**34**), transaction service provider class (**40**), locking service provider class (**42**), action service provider class (**44**), and query relation service provider class (**46**). The software classes for service providers **32, 34, 40, 42, 44**, and **46** can be implemented as ABAP global classes maintained by the ABAP class library using the ABAP development environment available from SAP of Walldorf, Germany. They also can be implemented by any other programming language on any other platform, e.g., Java on Linux or C# on Windows.

Repository service provider **30** handles requests to get or modify meta data from repository **18**. Query service provider **32** handles queries on data in backend database **24** from front end application program **12**. Aspect service provider **34** handles accessing and modifying data, navigation through relations, and calling actions. The aspect service provider **34** has a standard set of methods that correspond to the standard operations on aspects that can be requested from the service manager **16**. These standard operations

include select, insert, update, delete, select by relation, and update fields. Transaction service provider **40** allows business logic to act on different states of a transaction between front end application program **12** and service providers **26**. Locking service provider **42** enables separation of concurrent accesses on data types in backend database **24**. Action service provider **44** enables execution of actions on aspects. Query relation service provider **46** is the interface for the target aspect of a relation. In some examples, service manager **16** can have different multiple instances of service providers **32, 34, 40, 42, 44,** and **46** for different elements in repository **18** representing services. Upon receiving a request for a service represented by an element in repository **18**, the service manager **16** can look up a name of a service provider (e.g., **32, 34, 40, 42, 44,** and **46**) in the meta data for the element in repository **18**. For example, the meta data describing an aspect in repository **18** defines which aspect service provider **34** is designed to handle services for the aspect. The service manager **16** uses this information in the meta data to direct requests from the front end application program **12** to the appropriate aspect service provider **34**. Similarly, the meta data describing a query in repository **18** defines which query service provider **32** is designed to handle services for the query.

The interface provided by the service manager **16** provides requests or commands to front end application program **12**. As mentioned previously, standard commands select, insert, update, delete, select by relation, and update fields are standard operations on aspects in the repository **18**. These standard operations are provided by aspect service provider **34** and correspond to some of the requests or commands available to front end application program **12**. A "Select" command provides a capability such that if the identifiers (or keys) of instances of a data type (e.g., stored in database **24**) provided by aspect service provider **34** are known, front end application program **12** can select and read the attributes of these instances. An "Insert" command allows front end application program **12** to add new instances of a data type (e.g., stored in database **24**) provided by aspect service provider **34**. A "Select By Relation" command provides a capability that if a data type is known, front end application program **12** can find other data types that have relations to this data type as defined in repository **18**. An "Update" command provides a capability to modify instances of data types (e.g., stored in backend database **24**) provided

by aspect service provider **34**. A "Delete" command provides the capability to delete one or more selected instances of one or more data types (e.g., stored in backend database **24**) provided by aspect service provider **34**.

An "Execute" action command provides a capability to execute a semantically defined action on one or more instances of one or more data types (e.g., stored in database **24**) provided by aspect service provider **34**. Either the aspect service provider **34** or the action service provider **44** executes the Execute action command. A "Query" command provides a capability to search and find particular data of interest. The Query command is a method with a fixed set of search parameters and a result set with a defined structure. Queries are defined for particular service modules, or clusters of aspects in the meta data of the repository **18**. The query service provider **32** executes a Query command.

The meta data in repository 18 is classified into data types or classes. The names of meta model classes representing the data type classifications in repository **18** have the suffix "descriptor" to express their belonging to the meta model and to differentiate them from runtime classes used by service manager **16**. Descriptors of classes of the meta data of the repository **18** and their class relations are illustrated using an Unified Modeling Language (UML) class diagram **50** in FIG. 4.

Comparing the meta data to data described by relational database terminology, an aspect in the repository **18** can represent a class or an entity type fully or partially stored in backend database **24** and an aspect descriptor **56** includes attributes for the entity type in addition to other information about the entity type. The meta data in the repository **18** also can include relations descriptors **84** defining relations between aspects that can be implemented in database **24** as relationships using foreign keys in relational databases. The meta data also can include service modules descriptors **54** representing service modules that are aggregations of aspects and have predefined queries for accessing data in database **24**.

The service modules defined in repository **18** are the building blocks for a set of applications (e.g., front end application program **12**) in business software architecture **2** for a particular application area or industry. The service modules encapsulate the implementation and business logic and provide access to data and functionality in a

unified canonical way. Examples for service modules in repository **18** are "business partner", "employee", "sales order", or "business activity". Service module descriptor **54** describe services modules in the data model of the meta data of the repository **18** and how the service modules can be accessed by queries from application program **12**.

In repository **18**, each defined query is an entry point to search instances of a data type (represented by an aspect) provided by service providers **26** via service manager **16**. A "key" is an identifier of an instance of a data type provided by service providers **26**. An "action" is a specialized method on one or more instances of an aspect. A "structure" is the aggregation of attributes representing the data of an aspect. A "relation" is the relation between objects of a source and a target aspect. A service module group is associated with a service module and is an aggregation of aspects, relations, and queries. An aspect group is associated with an aspect and is an aggregation of relations, aspect actions, and field descriptors **86**. The meta data in the repository **18** also includes a text description of each aspect, query, key, action, structure, relation, service module group, and aspect group that is included in the available back end (e.g., backend database 24). So, the organization of the meta data in the repository **18** can be described in terms of those data types (e.g., aspect, query, key, action, structure, relation, service module group, and aspect group).

The data model for attributes of aspects, queries, keys, and actions is based on structure descriptors **74**. In one example, every aspect has one structure descriptor **74** that defines the data attributes of the aspect. Structure descriptors **74** refer to a data dictionary in repository **18**. A data dictionary is a collection of descriptions of the data objects or items in a data model for the benefit of programmers and others who need to refer to them. The structure descriptors **74** can be defined in an XML Schema or in one or more database tables in repository **18**.

In one example, structure descriptors **74** defined in repository **18** include flat structures in database tables. A flat structure is a sequence of pairs of attribute names and field descriptors **86** of simple value types such as real, integer, character string, and Boolean. For instance, a structure descriptor **74** defining a two dimensional point can be a list {X, real, Y, real}, where X and Y are attribute names having real values.

In another example of the repository **18**, structure descriptors **74** can include nesting and collections of other structure descriptors **74**. Nesting of other structure descriptors **74**, or sub-structures, to enable the generation of larger aspects is useful whenever the use of keys for sub-structures defining smaller aspects does not make sense.

For front end application program **12** to access data (e.g., data stored in backend database **24**) from service providers **26** through the service manager **16**, instances of business object classes are identified by unique keys within a service module, for example the number of an order or the id of a product. To differentiate between different types of keys for different aspects in a service module, key descriptors **64** define different types of keys. A key descriptor **64** is associated with a structure descriptor **74** that can include more than one data attribute. In one example, every key has a character string attribute. A service module can be associated with different key descriptors **64** for different aspects, e.g., an order key may have another key descriptor **64** as an order item key.

Service module descriptor **54** includes a collection of aspect descriptors **56**. An aspect descriptor **56** refers to one structure descriptor **74** and one key descriptor **64**. The structure descriptor 74 includes all key attributes of the corresponding key descriptor 64. Key descriptors 64 are specialized aspect descriptors 56. The key descriptor 64 attribute of a key refers to itself as a self-reference. Examples for aspect descriptors **56** within a simple sales order service module can include: Order, Order Detail, Shipping Address, Billing Address, and Order Item as well as descriptors for key aspects like Order ID and Order Item Key. Service module descriptor **54** specifies the collection of supported aspect descriptors **56**. Multiple service module descriptors **54** can be associated with the same aspect descriptor **56**.

Aspect descriptors **56** relate to each other specified by relation descriptors **84**. A relation descriptor **84** has one source aspect descriptor **56** and one target aspect descriptor **56**. In this sense, relation descriptors **84** are directed. Relation descriptors **84** also have an optional cardinality (e.g., 1..n) and a category. Supported categories are, for example, Parent-Child or Child-Parent.

A relation descriptor **84** defining a relation between source aspect A and target aspect B means that it is possible to traverse from instances of aspect A to instances of

aspect B. For example, given that aspects A and B are implemented in backend database **24** as relational database tables, this means that one or more fields in a table corresponding to aspect A point to the primary key of a table corresponding to aspect B. The relation descriptor **84** defining a Parent-Child relation from source aspect A and target aspect B means that aspect B depends on the existence of aspect A. For example, given that aspects A and B are implemented in backend database **24** as relational database tables, this means that a primary key of a table corresponding to aspect B is derived from a table corresponding to aspect A. Relation descriptors **84** are introduced to describe internal navigation from one aspect to another within the same service module, e.g., from an order to the shipping address (cardinality 1..1) or to the order items (cardinality 1..n) within a sales order service module. Relation descriptors **84** are independent of service modules and can be reused by different service modules. For an internal navigation or traversal from one data type to another in backend database **24**, the visible (usable) relation descriptors of a source aspect descriptor **56** are defined by the service module descriptor **54**, which has a list of supported relation descriptors **84**. Navigation is allowed for those supported relation descriptors **84** that have a target aspect descriptor **56** that is also supported by the service module descriptor **54**.

Operations for accessing and acting on data types in backend database **24** are described in operation descriptors **70**. The structure descriptor **74** defines input parameters of the operation descriptor **70**. This structure descriptor **70** also includes an input key descriptor **64** that enables mass and filter operations. Mass operations are operations specified by front end application program **12** on multiple instances of a data type in backend database **24**. Filter operations filter the results of an operations, e.g., a query, by the keys defined by the input key descriptor. Input parameters for operation descriptors **70** are optional.

There are three types of operation descriptors **70** i.e., query descriptors **104**, aspect action descriptors **92**, and action descriptors **96**. The aforementioned commands Query and Execute action are defined by operation descriptors **70**.

Query descriptors **104** describe query methods that allow searching for instances of aspects within a service module. The query descriptor **104** includes an input parameter,

an input key descriptor **64**, and a result aspect descriptor **56**. The input parameter is a structure descriptor **74** that defines the search parameter structure of the query. The input key descriptor **64** defines which keys may be used for filtering. For example, executing a query defined by a query descriptor **104** with filtering keys results in a list of keys meeting the criteria of the first input. This list of keys is filtered by the set of filtering keys of the input key descriptor **64** so that a subset of the list of keys can be returned. The result aspect descriptor **56** for the query descriptor **104** specifies the type of result of the query, which could be any aspect descriptor **56** that is associated with the service module.

Each service module descriptor **54** has a set of supported query descriptors **104**. Service module descriptors **54** cannot use query descriptors **104** defined in other service module descriptors **54** since the query descriptor **104** belongs to one service module descriptor **54**.

Aspects provide additional operations (beyond the standard operations select, insert, update, delete, select by relation, and update fields) in the form of actions, which are described by aspect action descriptors **92**. Aspect action descriptors **92** are specialized operation descriptors **70** on aspects. The aspect descriptor **56** can have a set of supported aspect action descriptors **92**. The input parameter for an aspect descriptor **96** defines the parameter structure of the action. The input key descriptor **64** specifies which keys may be used for mass operations, e.g., an email action may have as input a list of keys representing multiple emails.

Action descriptors **96** can define actions for multiple actions like Print, Email, Fax, Approve, Clear, Cut, Copy, Paste and Cancel. But there also may be more aspect specific actions that can be only used for one or a few aspects. Action descriptors **96** are introduced to enforce reuse. Each aspect action descriptor **92** is associated with an action descriptor **96**, where the name and the meaning (textual description) are defined.

Action descriptors **96** specify a name and the meaning (textual description) of the action. They do not specify parameters and are not used to describe polymorphic behavior of operations. They can be used for taxonomies.

A service module group descriptor **58** can be associated with aspect descriptors **56**, relation descriptors **84**, and query descriptors **104**. An aspect group descriptor **78** can

be associated with relation descriptors **84**, aspect action descriptors **92**, and field descriptors **86**.

The diagram **50** includes a zero or more to zero or more relationship **52** between service module descriptor **54** and aspect descriptor **56**, since multiple instances of aspects can be associated with multiple instances of service modules. Service module group descriptor **58** has a zero or more to zero or more directed relation **60** towards aspect descriptor **56** since aspects can be grouped together in a service module group. Service module group descriptor **58** also has a zero or more to one composite aggregation relationship **62** with service module descriptor **54** because service module groups can be aggregated together in a service module. Key descriptor **64**, as a specialization of aspect descriptor **56**, has an inheritance relationship **66** with aspect descriptor **56**. Key descriptor **64** also has a one to zero or more relationship **68** with aspect descriptor **56**, since each aspect has a key associated with that aspect to uniquely identify instances of the aspect. Operation descriptor **70** has a directed zero or more to zero or more relationship **72** with key descriptor **64**, since operations can include input keys. Aspect descriptor **56** has a zero or more to one relationship **76** with structure descriptor **74** since each aspect descriptor **56** can have a structure descriptor **74** defining its attributes. Aspect group descriptor **78** has a zero or more to one composite aggregation relationship **80** with aspect descriptor **56** since an aspect can be an aggregation of aspect groups. Aspect group descriptor **78** also has a directed zero or more to zero or more relationship **82** with relation descriptor **84** since aspect groups also include relations. Structure descriptor **74** has a one to zero or more ownership relationship **90** with field descriptor **86** since a structure can use many data fields to define itself. Aspect group descriptor **78** also has a zero or more to zero or more relationship **88** with field descriptor **86**.

Aspect action descriptor **92** has a zero or more to one aggregation relationship **100** with aspect descriptor **56** since aspects can provide actions that can be executed on the aspect. Aspect action descriptor **92** has an inheritance relationship **102** with its superior class operation descriptor **70**. Query descriptor **104** also has an inheritance relationship **106** with its superior class operation descriptor **70**. Service module descriptor **54** has a one to zero or more relationship **108** with query descriptor **104** since a service module can

include zero or more queries. Service module group descriptor **58** has a zero or more to zero or more directed relationship **110** with query descriptor **104** since queries can also be grouped together in a service module group.

Operation descriptor **70** has a zero or more to zero or one relationship **112** with structure descriptor **74** since each operation includes input parameters in the form of structures. Query descriptor **104** has a zero or more to zero or one relationship **114** with aspect descriptor **56** since queries include a resulting aspect. Relation descriptor **84** has zero or more to one relationships **116** and **118** with aspect descriptor **56** since relations have source and target aspects.

To illustrate these descriptors defining an organization of the meta data in repository **18**, the examples below use a fixed set of relational database tables. Other persistence mechanisms (e.g., XML) can also be used. The relational database tables are defined in Tables 1-6, where each row of Tables 1-6 defines a field or column of the relational database tables. The main data type of repository **18** is the aspect. The database tables for describing an aspect are Table 1, SCOL_ASPECT, and Table 2, SCOL_ASP_ACTION. Table 1 includes descriptions of properties of an aspect. The key field for Table 1, SCOL_ASPECT, is the ASPECT_NAME field because an aspect's name is unique for an aspect. The ASPECT_CATEGORY field indicates if the aspect represents a non-key aspect or a key aspect. The STRUCTURE field indicates a data structure name for data attributes of the aspect. A key is associated with an aspect by putting the key's name in the KEY_ASPECT field. The SERVICE_PROVIDER field defines the aspect service provider **34** for an aspect. The TRANSAC_PROVIDER field defines the transaction service provider **40** for an aspect. The LOCKING_PROVIDER field defines the locking service provider **42** for an aspect. The repository **18** can also have a corresponding table for the description of an aspect.

Table 1. SCOL_ASPECT definition

Field Name	Key	Description
ASPECT_NAME	X	Name of the aspect
ASPECT_CATEGORY		Aspect type: aspect or key aspect
STRUCTURE		The corresponding data structure of the aspect
KEY_ASPECT		The corresponding key aspect
SERVICE_PROVIDER		The name of the corresponding aspect service provider class
TRANSAC_PROVIDER		The name of the corresponding transaction provider class
LOCKING_PROVIDER		The name of the corresponding locking provider class

Aspects can provide actions that can be executed on the aspect. Descriptions of the actions are stored in Table 2, SCOL_ASP_ACTION. The actions are uniquely denoted by the aspect name and the name of the action so ASPECT_NAME and ACTION_NAME fields are key fields for SCOL_ASP_ACTION table. The field PARAM_STRUCTURE refers to a data structure that holds input data parameters for the action. The field INPUT_KEY_ASPECT refers to the name of a key aspect that defines the type of keys used to designate which instances of data types in repository 18 are acted upon by the action. The field PROVIDER_CLASS refers to the name of the action service provider class providing the action from the service provider implementing the aspect named in ASPECT_NAME field.

Table 2. SCOL_ASP_ACTION definition

Field Name	Key	Description
ASPECT_NAME	X	Name of the aspect
ACTION_NAME	X	Name of the Action
PARAM_STRUCTURE		The corresponding data structure of the input parameters
INPUT_KEY_ASPECT		The name of the key aspect of the input aspects
PROVIDER_CLASS		The name of the action service provider class

Aspects can be related with each other. Descriptions of the relations between aspects are stored in Table 3, SCOL_RELATION. A relation is uniquely defined by its name so the key of a relation table is the relation name specified in field

RELATION_NAME. For each relation, the field SOURCE_ASPECT defines the aspect that is the source of the directed relation, the field TARGET_ASPECT defines the aspect that is the target of the directed relation, the field TARGET_PROVIDER defines the query relation service provider for the target aspect, the field REL_PARAM_TYPE defines the type of the relation (Parent-Child or Child-Parent), and the field REL_PARAMETER defines the cardinality of the relation. The repository **18** can also have a corresponding table for the description of a relation.

Table 3. SCOL_RELATION definition

Field Name	Key	Description
RELATION_NAME	X	Name of the relation
SOURCE_ASPECT		Name of the source aspect of the relation
TARGET_ASPECT		Name of the target aspect of the relation
TARGET_PROVIDER		Name of the query relation service provider class
REL_PARAM_TYPE		Type of the relation
REL_PARAMETER		Parameter of the relation

The properties of a service module are stored in the Table 4, SCOL_SVC_MODULE. Each Service module is uniquely described by its name so SVC_MODULE_NAME field is the key field for a SCOL_SVC_MODULE table. For each service module, the field TRANSAC_PROVIDER specifies the name of the transaction provider **40** for the service module. The repository **18** also has a corresponding table for the description of a service module.

Table 4. SCOL_SVC_MODULE definition

Field Name	Key	Description
SVC_MODULE_NAME	X	Name of the service module
TRANSAC_PROVIDER		The name of the corresponding transaction service provider class

Every service module is associated with aspects that can be used within the service module. Names of the aspects that can be used within each service module are stored in the Table 5, SCOL_ASPECT_USE. Since each aspect-service module usage is uniquely

described by a name of a service module and the name of an aspect, the fields SVC_MODULE_NAME and ASPECT_NAME are the keys for SCOL_ASPECT_USE table.

Table 5. SCOL_ASPECT_USE definition

Field Name	Key	Description
SVC_MODULE_NAME	X	Name of the service module
ASPECT_NAME	X	Name of the aspect

Service Modules can provide queries to retrieve data. Descriptions of the queries of a service module are stored in the table SCOL_QUERY illustrated in Table 6 below. The structure of the database table is defined in Table 6. Since each query is uniquely defined by a service module and a query name, the fields SVC_MODULE_NAME and QUERY_NAME are key fields for SCOL_QUERY table. Other fields include RESULT_ASPECT that specifies the name of an aspect defining the data type returned by the query and PARAM_STRUCTURE that specifies a data structure containing the input parameters for the query. For example, a query done on a particular aspect (e.g., specified in field RESULT_ASPECT) associated with the service module can include input parameters that are matched with attributes of instances of the particular aspect and the matching instances are returned as a dataset of keys referring to those instances. The field INPUT_KEY_ASPECT is used to define the key aspect describing keys that could be used as filters for the query. The PROVIDER_CLASS specifies the name of the query service provider **32** associated with each query. The repository **18** also has a corresponding table for the description of a query.

Table 6. SCOL_QUERY definition

Field Name	Key	Description
SVC_MODULE_NAME	X	Name of the service module
QUERY_NAME	X	Name of the query
RESULT_ASPECT		Name of the result aspect of the query
PARAM_STRUCTURE		The corresponding data structure of the input parameters
INPUT_KEY_ASPECT		The name of the key aspect of the input aspects
PROVIDER_CLASS		The name of the corresponding query provider class

As stated previously, architecture **38** includes six service provider classes (i.e., transaction **40**, query **32**, aspect **34**, action **44**, query relation **46**, and locking **42**) for handling requests from front end application program **12**, other than requesting meta data from repository **18**, which is handled by repository service provider class **30**. To provide services upon request by front end application program **12**, service manager **16** directly calls instances of service provider classes. These instances of service provider classes can be located on the same computer (e.g., **6**) as service manager **16** or on a different computer.

The locking service provider **42** can be used to implement a generic lock manager for a single aspect or a set of aspects. Each locking service provider **42** needs to be registered with an aspect. The name of the locking service provider **42** is set in SCOL_ASPECT table in LOCKING_PROVIDER field for each aspect. Locking service provider class has two methods that can be called by service manager **16**. These are LOCK and UNLOCK. LOCK takes as input a collection of keys representing business objects to be locked, a name of an aspect representing a class of the business objects, and a lock mode. There are various locking modes depending on the locking capability of the target system. Locking mode can specify “E”, “S”, or “SP”. “E” means an exclusive lock or that only one client can obtain the lock. “S” means a shared lock indicating that any clients can lock and no lock exclusive to one client is possible. “SP” means the same as “S” but a subsequent upgrade to an exclusive lock is possible.

LOCK method outputs a Boolean value indicating if the request is rejected or not and also outputs a return code. UNLOCK takes as input a collection of keys representing

business objects to be unlocked and a name of an aspect representing a class of the business objects to be unlocked. UNLOCK method also outputs a Boolean value indicating if the request is rejected or not and a return code. A call to UNLOCK is rejected if a transactional buffer is already in a "dirty" state, i.e. if any update, insert, delete operation or an action that is not marked as COL_AFFECTS_NOTHING has been issued since the last CLEANUP call. All locks are removed if the CLEANUP method (described below) of the transaction service provider class is called with reason 'END'.

A transaction is a sequence of information exchange and related work (such as database updating) that is treated as a unit for the purposes of satisfying a request from front end application program **12** to service manager **16** and for ensuring integrity of backend database **24**. For a transaction to be completed and changes to database **24** to be made permanent, a transaction has to be completed in its entirety. All of the steps of a transaction are completed before the transaction is successful and the database is actually modified to reflect all of the requested changes. If something happens before the transaction is successfully completed, any changes to the backend database **24** must be kept track of so that the changes can be undone.

To handle transactions, the transaction service provider **40** receives notifications on the various states of a transaction between service manager **16**, another non-transaction service provider (e.g., **32, 34, 44, 46**), and front end application program **12** (or service manager proxy **14** in some cases). These notifications are the transaction service provider **40**'s methods BEFORE_SAVE, CLEANUP, and SAVE that are called by the service manager **16** during transactions.

The service manager **16** calls the transaction service provider **40**'s method BEFORE_SAVE to check if the transactional buffer can be saved. This allows checking if the internal state of the non-transaction service provider is ready for being saved. The method BEFORE_SAVE returns false if it is not possible to save the transactional buffer, then the transaction end is aborted. Thus, the BEFORE_SAVE method has a BOOLEAN return parameter. BEFORE_SAVE takes a Boolean as an input parameter REJECTED. The transactional service provider **16** can prevent the following save and commit operations by setting the REJECTED parameter to a non-initial value, i.e. to "true". The

method BEFORE_SAVE is called within the service manager's 16's sequence of operations triggered by the front-end application 12's SAVE method.

The SAVE method finally triggers the application to save the transactional buffer to the database 24. By calling SAVE, all internal states of a non-transaction service provider are made persistent – either by direct updates or by creating appropriate calls to the update task. If all service providers in architecture 38 have received a SAVE request, service manager 16 commits the transaction.

The CLEANUP method tells all non-transaction service providers to release all their transactional buffers and enqueue-based locks. Calling CLEANUP method communicates that all service providers in architecture 38 need to clean up their internal state. CLEANUP takes a REASON string as an input parameter. The REASON field indicates the reason for the clean up operation. This can be either a 'COMMIT' due to a SAVE-operation or the 'END' of the transaction due to the system closing the transaction automatically. There is no guarantee that cleanup is called under failure conditions.

The action service provider 44 is called by service manager 16 to execute an action for an aspect. The name of action service provider 44 is set in the PROVIDER_CLASS field of SCOL_ASP_ACTION table for a row corresponding to an action. Action service provider 44 has one method EXECUTE. EXECUTE method takes as input parameters an aspect name (ASPECT), a set of keys (INKEYS) specifying which instances of the aspect are acted upon by the action, a generic input parameter (INPARAM), the name of the action (ACTION) to be executed, a set of keys (RELATION_INKEY) for an action acting on an relation, and a name of the relation (RELATION). EXECUTE method returns as output parameters the changed or newly created objects (OUTRECORDS), which have been modified by the action. The objects returned by the OUTRECORDS parameter are transported to application program 12.

The aspect service provider 34 is called by service manager 16 to provide functionality to read and modify the content of one or more aspects. As described previously, an aspect is described by its name (the name is globally unique within a repository), an associated data structure, an associated key (i.e. identifier) structure, a set of implemented actions, a set of outgoing relations, and a set of incoming relations.

Aspect service provider 34 has methods EXECUTE, SELECT, INSERT, UPDATE, DELETE, SELECT_BY_RELATION, and UPDATE_FIELDS.

The method EXECUTE is derived from the action service provider 44 and allows executing an action. EXECUTE has as input parameters a name (ASPECT) of the aspect, where the action is to be executed on, keys (INKEYS) of the objects, where the action is executed on, parameters (INPARAM) for the actions, name (ACTION) of the action. Returned parameters include modified or created aspect rows (OUTRECORDS), a Boolean flag (REJECTED) indicating if the request for the method was rejected or not, and return codes (RETURN_CODES).

The method SELECT reads the aspect data associated with the input keys for a given aspect. SELECT has as input parameters a list of keys (INKEYS) encoded within the associated key structure to describe the aspect rows to read and the name (ASPECT) of the aspect. SELECT has as output parameters the result (OUTRECORDS) encoded in the aspect data structure, a Boolean flag (REJECTED) indicating if the request for the method was rejected or not, and return codes (RETURN_CODES).

The method INSERT inserts new data into an aspect. INSERT includes as input parameters a table containing the records to be inserted, if aspect is designed for row wise write operations (INRECORDS). The method may allow the inserted record to also define key fields, depending on the aspect description (e.g., a parameter ExternalKeys = true or false). Input parameters also include the name (ASPECT) of the aspect, a set of keys (RELATION_INKEY) for an action acting on a relation, and a name of the relation (RELATION). Method INSERT returns a set of records (OUTRECORDS) representing the inserted records together with their keys and possible other modifications that aspect service provider 34 wants to do on the inserted records. For example one modification can be filling out calculated fields for the set of records. The order of the OUTRECORDS rows has to correspond to the order of the INRECORDS rows. Other output parameters include a Boolean flag (REJECTED) indicating if the request for the SELECT method was rejected or not and return codes (RETURN_CODES).

The UPDATE method updates existing instances of an aspect either record wise or field wise. The input parameters for UPDATE method include a table (INRECORDS)

containing the instance keys to be updated, if the aspect is designed for row wise write operations. Input parameters also include the name (ASPECT) of the aspect. Parameters returned by the UPDATE method include the updated records (OUTRECORDS) together with their keys and possible other modifications the service provider wants to do. The order of the OUTRECORDS rows can correspond to the order of the INRECORDS rows. Other output parameters include a Boolean flag (REJECTED) indicating if the request for the SELECT method was rejected or not and return codes (RETURN_CODES).

The DELETE method deletes rows or instances of an aspect in the backend (e.g., backend database 24). Input parameters for DELETE method are a list of keys (INKEYS) encoded within the associated key structure to describe the aspect rows to be deleted and the name (ASPECT) of the aspect. Parameters returned by the DELETE method include a Boolean flag (REJECTED) indicating if the request for the DELETE method was rejected or not and return codes (RETURN_CODES).

The SELECT_BY_RELATION method returns, depending on the relation parameter description, either attributes to follow a relation or another aspect, where the source aspect has a relation pointing to that other aspect. Input parameters for SELECT_BY_RELATION are name (RELATION) of the relation to follow, records (INRECORDS) of the source aspect, name of the source aspect (ASPECT), and a structure (OPTIONS) describing various options of the queries for paging, etc. Output parameters returned by SELECT_BY_RELATION include the result encoded in the target aspect data structure (OUTRECORDS), an index table showing which row of the OUTRECORDS parameters belongs to which INRECORDS row (INDEX), a description of the result (DESCRIPTION), a Boolean flag (REJECTED) indicating if the request for the SELECT_BY_RELATION method was rejected or not and return codes (RETURN_CODES).

The UPDATE_FIELDS method updates fields of instances of an aspect. Input parameters include a list of keys (INRECORDS) encoded within the associated key structure to describe the instances of the aspect to be updated. Input parameters also include a table (INFIELDS) containing pairs of names of fields and corresponding values to be updated within a set of records, if the aspect is designed for field wise write

operations. If more than one instance of an aspect is to be updated, the additional field index INKEY points to the associated key record. Input parameters also include the name (ASPECT) of the aspect. Parameters returned by UPDATE_FIELDS include the created or changed instances of the aspect (OUTRECORDS) together with their keys and possible other modifications performed by the aspect service provider **34**. The index of the various OUTRECORDS rows have to be associated to the row indexes in the INFIELDS table. Other parameters returned include a Boolean flag (REJECTED) indicating if the request for the UPDATE_FIELDS method was rejected or not and return codes (RETURN_CODES).

Query service provider **32** performs queries. A query in the repository **18** is described in table SCOL_QUERY by the query name in field QUERY_NAME, the associated parameter structure in field PARAM_STRUCTURE, the associated result aspect in field RESULT_ASPECT, and optionally, the associated aspect key, with its unique data structure in field INPUT_KEY_ASPECT. Query service provider **32** has one EXECUTE method that performs a query on one or more aspects. Input parameters include the name of the query (QUERY), a data structure (INPARAM) containing the parameters for the query, and an optional table-type parameter (INKEYS), containing the keys of the aspect rows to which the query shall be restricted. INKEYS can but does not have to consist of the keys of OUTRECORDS returned by EXECUTE method. INKEYS can be of any key aspect structure. Which key structure is associated to the query is specified in the repository **18** in table SCOL_QUERY in field INPUT_KEY_ASPECT. Optionally, other input parameters can be specified including a structure describing various options (OPTIONS) of the queries (e.g., for paging) and SELECTIONS.

Parameters returned by EXECUTE method include a description (DESCRIPTION) of the query, the query result (OUTRECORDS), and a Boolean flag (REJECTED) indicating if the request for the EXECUTE method was rejected or not

The EXECUTE method returns the results specified by the query parameters. If the INKEYS table parameter is not empty, the result is restricted to the objects that fulfill the query parameters. INKEYS and INPARAM both restrict the query, but are used in different ways. For example, a query can be defined that returns a list of orders not yet

delivered. In such an example, the structure INPARAM can specify that only orders from customers with last names from A-D are to be returned. The INKEYS is a table of all orders that have not yet been delivered. OUTRECORDS contains all orders from the relevant customers, in this case with last names A-D, that have not been delivered yet. In one example, the OUTRECORDS result of a query is a disconnected aspect, that is, the aspect is always read-only. No further backend operations can be performed on this aspect. In this example, the received keys can be used as parameters to select other aspect rows using the aspect service provider **34** and, for example, its SELECT method.

The query relation service provider **46** implements a routine in a service provider (e.g., aspect service provider **34**) for an aspect that is the target of a relation. Methods of query relation service provider **46** are indirectly called from the aspect service provider **34** of the source aspect, if the relation is marked as SOURCE_KEYS or ATTRIBUTES.

Query relation service provider **46** has a SELECT_TARGET method. The method SELECT_TARGET has input parameters as follows. Input parameters include the name (SOURCE_ASPECT) of the source aspect. Optionally, the method also includes an input parameter defining a proxy interface (TARGET) to the target aspect's SELECT method. Specifying the TARGET parameter allows calling the SELECT method of the aspect service provider **34** for the target aspect without directly knowing the aspect service provider **34** for the target aspect. This enables a query relation service provider **46** to be added to a service module without knowledge of the aspect service provider **34** for the target aspect.

Another input parameter for the SELECT_TARGET method is the relation (RELATION). Another input parameter is a table of fields (INPARAMS) to describe the relation. To allow mass selection, INPARAMS is a table where every row describes a single selection. An INDEX parameter is used to relate the various rows of the INPARAMS structure to the OUTRECORDS rows. Another optional input parameter is a structure (OPTIONS) describing various options of the queries (e.g., for paging).

The SELECT_TARGET method returns parameters that include the result encoded with the structure of the target aspect (OUTRECORDS), a description of the query result (DESCRIPTION), and a proxy interface to the target aspects SELECT

method. Other output parameters include an index (INDEX) to describe the relation between the INPARAMS records and the OUTRECORDS parameter, a Boolean flag (REJECTED) indicating if the request for the SELECT_TARGET method was rejected or not and return codes (RETURN_CODES).

The service providers 32, 34, 40, 42, 44, and 46, as described above, enable the following transactional model for the architecture 38. Executing method SELECT of aspect service provider 34 reads from the backend database 24 or reads from a transactional buffer stored in the back-end. Aspect service provider 34 merges data from both sources – the database and its transactional buffer - in a consistent way so that the merge data reflects the updates made so far in this transaction. Next, executing UPDATE, INSERT, MODIFY, or DELETE methods of aspect service provider 34 builds up a transactional buffer. Before actually changing data in the transactional buffer, the service manager 16 has to acquire a transactional lock on the data and read the data under the protection of a lock. There are exclusive, shared, and shared promotable lock modes available using locking service provider 42 as described previously. Locking has to be accompanied by selecting the locked data again under the protection of the lock. Applications can support optimistic locking by providing time-stamped or otherwise versioned data, and merging actual and modified data on the front-end in case of conflicts.

The BEFORE_SAVE method of the transaction service provider 40 enables all participating service providers to declare if they are ready for saving the transactional buffer. The SAVE method of the transaction service provider 40 finally triggers service manager 16 to save the transactional buffer to the backend database 24.

The CLEANUP method of the transaction service provider 40 notifies all service providers (e.g., aspect service provider 34) to release all their transactional buffers and enqueue-based locks. If CLEANUP is called with reason 'END', all locks have to be released. If reason is set to 'COMMIT', each service provider can chose to keep its locks. Aspect service provider 34 must not call COMMIT WORK or ROLLBACK WORK internally on its own. The service manager 16 enforces this by automatically aborting the transaction if aspect service provider 34 is trying to commit a transaction.

The supported locking models and lock policies are as follows. Using policy S,

many participants can obtain a shared lock. If a shared lock is obtained on an object, no exclusive lock or SP lock can be obtained. Shared locks can only be used to achieve a consistent view on a larger set of data during read operations. Using policy E, only a single participant can obtain a lock. Using policy SP (shared promotable), many participants can obtain the lock. If a SP lock exists, exclusive locks can only be obtained by participants already having a SP lock on the object. Only one of the participants can upgrade the lock to an exclusive lock. No other participant, who did obtain a lock prior to the upgrade, can upgrade to exclusive even if the first participant did release its lock.

Example

The architecture 38 (of FIG. 3) implements a simple task of creating a new customer, receiving the customer's order of one or more products via GUI 28 and submitting the order to a business process. To support this example, backend database 24 can be implemented using a relational database designed according to the definitions in Tables 1-6 above to define lists of customers, addresses, product types, baskets, positions of products in a basket for each order, and orders. In Tables 7-12, key field headings are denoted with an asterisk. Customers Table 7 defines customers and each customer is uniquely identified by a CustomerId field. Customers Table 7 also includes a NAME field and a foreign key field AddressId that links addresses in an Addresses table to customers.

Table 7. Customers

CustomerId*	NAME	AddressId
1	John Smith	1
2	David Klein	2

Addresses Table 8 defines addresses having a town and a street. The Address id itself is a valid unique key for an address and the connection between address and customer is done through the Customers Table 7 (AddressID field).

Table 8. Addresses

AddressId*	Town	Street
1	Athens	Main Street
2	Louisville	Willow Avenue

Table 9 defines products having names with key ProductId.

Table 9. Products

ProductId*	Name
1	Saw
2	Hammer
3	Wrench
4	Screwdriver

Table 10 defines shopping baskets having customers with key BasketId.

Table 10. Baskets

BasketId*	CustomerId
1	2
2	1

Table 11 defines positions of orders in baskets and having products. Positions are dependent on the existence of baskets and orders so the primary key for positions is a combination of PositionId, BasketId, and OrderId.

Table 11. Positions

PositionId*	BasketId*	OrderId*	ProductId
1	1	3	2
2	1	2	3
3	2	1	4

Table 12 defines orders having customers and indicating whether or not each order is submitted with primary key OrderId.

Table 12. Orders

OrderId*	CustomerId	Submitted
1	1	False
2	2	False
3	2	False

As shown in FIG. 5, process **150** defines the database operations on backend database **22** that are needed for this simple task using these tables 7-12. Process **150** includes front end application program **12** receiving **(152)** a name of a customer. Process **150** includes the business software application querying **(154)** a database with Customers table (Table 7) for the name in the NAME field. Process **150** includes checking if the customer's name matches **(156)** a row in the Customers table (Table 7). If no match is made, process **150** includes the business software application obtaining **(158)** the address of the customer, inserting **(160)** a new row in the Address table (Table 8) with a new AddressID and address, and inserting **(162)** a new row in the Customers table (Table 7) with a new CustomerId and the AddressID. If a match is made, process **150** includes the business software obtaining **(164)** a name of a product to order for the customer. Process **150** includes the business software querying **(166)** the Products table (Table 9) for the product name.

Process **150** includes checking if the product name matches **(168)** a row in the Products table (Table 9). If a match is made, then process **150** includes the business software inserting **(170)** a new order in the Orders table (Table 12) with the customer's CustomerId and setting the Submitted field to "False". Otherwise, process **150** returns to obtaining **(164)** the name of the product to order. Process **150** includes the business software inserting **(172)** a new basket in the Basket table (Table 10) with the customer's CustomerId.

Process **150** includes the business software inserting **(174)** a new position in the Positions table (Table 11) with the CustomerId, BasketId, and ProductId. Process **150** includes the business software receiving **(176)** a request to submit the order. Process **150** includes the business software querying **(178)** the Orders table (Table 12) by the customer's CustomerId and this query returns orders matching the customer's CustomerId. Process **150** includes the business software selecting **(180)** orders in the

Orders table (Table 12) matching the orders for the customer's CustomerId. Process **150** includes the business software setting **(182)** the Submitted field in the selected rows in the Orders table (Table 12) to "True". Process **150** includes the business software getting **(184)** the address of the customer from the Addresses Table 8 for order delivery by querying Customers Table 7 for an AddressId and then querying Addresses Table 8 for a matching AddressId.

Tables 13-19 show tables in one implementation of repository **18** representing meta data for the example database illustrated by Tables 7-12. Tables 13-19 follow the definitions of Tables 1-6 described above such that definitions in rows of Tables 1-6 correspond to columns or fields in Tables 13-19. As with Tables 7-12, key fields in Tables 13-19 are labeled by an asterisk.

Table 13 follows the definition of a SCOL_ASPECT table (defined in Table 1) to define aspects A_Customer, A_Address, A_Product, A_Basket, A_Position, and A_OrderHeader. Each aspect has a corresponding key aspect that defines a unique key for each instance. For example, aspect A_Customer has a key aspect Customer_Key. This key aspect in the meta data repository **18** can correspond to a key for a relational database table in backend database **24**. For example, the key for Customers table (Table 7) is CustomerId field. The rows in STRUCTURE field correspond to a data dictionary in Table 19 below. For example, Table 19 can define Customer_Structure to have a NAME field of type CHAR indicating a character string. The rows in SERVICE_PROVIDER field correspond to particular aspect service providers handling services for aspects. In Table 13, all of the aspects are assigned to S_provider aspect service provider (e.g., **34** referring to FIG. 3). The rows in TRANSAC_PROVIDER field correspond to particular transaction service providers **40** handling transactions for aspects. In Table 13, all of the aspects are assigned to T_provider transaction service provider (e.g., **40** referring to FIG. 3). The rows in LOCKING_PROVIDER field correspond to particular locking service providers handling locking for aspects. In Table 13, all of the aspects are assigned to L_provider locking service provider (e.g., **42** referring to FIG. 3).

Table 13. Example SCOL_ASPECT table

ASPECT_ NAME*	ASPECT_ CATEGORY	STRUCTURE	KEY_ ASPECT	SERVICE_ PROVIDER	TRANSAC_ PROVIDER	LOCKING_ PROVIDER
A_Customer	aspect	Customer_ Structure	Customer_ Key	S_provider	T_provider	L_provider
Customer_Key	key aspect	Customer_ Key_Table	Customer_ Key	S_provider	T_provider	L_provider
A_Address	aspect	Address_ Structure	Address_ Key	S_provider	T_provider	L_provider
Address_Key	key aspect	Address_ Key_Table	Address_ Key	S_provider	T_provider	L_provider
A_Product	aspect	Product_ Structure	Product_ Key	S_provider	T_provider	L_provider
Product_Key	key aspect	Product_ Key_Table	Product_ Key	S_provider	T_provider	L_provider
A_Basket	aspect	Basket_ Structure	Basket_ Key	S_provider	T_provider	L_provider
Basket_Key	key aspect	Basket_ Key_Table	Basket_ Key	S_provider	T_provider	L_provider
A_Position	aspect	Position_ Structure	Position_ Key	S_provider	T_provider	L_provider
Position_Key	key aspect	Position_ Key_Table	Position_ Key	S_provider	T_provider	L_provider
A_OrderHeader	aspect	OrderHeader_ Structure	OrderHeade r_Key	S_provider	T_provider	L_provider
OrderHeader_ Key	key aspect	OrderHeader_ Key_Table	OrderHeade r_Key	S_provider	T_provider	L_provider

Table 14 follows the definition of a SCOL_ASP_ASPECT table (defined in Table 2) to define an action Submit for aspect A_OrderHeader. Field INPUT_KEY_ASPECT specifies the key aspect that is sent by application **14** with the action to specify which instances of aspect A_OrderHeader should be acted upon by the action. Action Submit changes the Submitted field of those instances in backend database **24** to True. No extra parameters are required for this action Submit so PARAM_STRUCTURE field is blank in Table 14. Field PROVIDER_CLASS specifies the aspect service provider **34** (referring to FIG. 3) assigned to each action. In Table 14, action Submit is assigned to aspect service provider S_provider (e.g., **34** referring to FIG. 3).

Table 14. Example SCOL_ASP_ACTION Table

ASPECT_NAME*	ACTION_NAME*	PARAM_STRUCTURE	INPUT_KEY_ ASPECT	PROVIDER_ CLASS
A_OrderHeader	Submit		OrderHeader_ Key	S_provider

Table 15 follows the definition of a SCOL_RELATION table (defined in Table 3) to define relations between aspects defined in Table 13. These relations reflect relations between data tables in backend database **24** illustrated by example tables 7-12. These relations between aspects are also illustrated in FIG. 6 for aspect A_Customer **202**, aspect A_Address **204**, aspect A_Product **206**, aspect A_Basket **208**, aspect A_Position **210**, and aspect A_OrderHeader **112**. These relations include R_Customer_To_Address **212**, R_Basket_To_Customer **214**, R_OrderHeader_To_Customer **216**, R_Position_To_Product **218**, R_Position_To_OrderHeader **220**, and R_Position_To_Basket **222**.

Table 15. Example SCOL_RELATION Table

RELATION_ NAME*	SOURCE_ ASPECT	TARGET_ ASPECT	TARGET_ PROVIDER	REL_PARAM_ TYPE	REL_ PARAMETER
R_Customer_ To_Address	A_Customer	A_Address	S_provider	Parent-Child	
R_Basket_To_ Customer	A_Basket	A_Customer	S_provider		
R_OrderHeader To_Customer	A_OrderHeader	A_Customer	S_provider		
R_Position_To_ Product	A_Position	A_Product	S_provider		
R_Position_To_ OrderHeader	A_Position	A_OrderHeader	S_provider	Child-Parent	
R_Position_To_ Basket	A_Position	A_Basket	S_provider	Child-Parent	

Table 16 follows the definition of a SCOL_SVC_MODULE table (defined in Table 4) to define example service modules for the example definitions of backend database **24** given in tables 7-12. Table 16 defines service modules S_Customer, S_Product, S_Basket, and S_Order. Field TRANSAC_PROVIDER specifies a transaction service provider **40** (referring to FIG. 3) to each service module. In Table 16, transaction service provider T_provider (e.g., **40**, referring to FIG. 3) is assigned to the

service modules.

Table 16. Example SCOL_SVC_MODULE Table

SVC_MODULE_NAME*	TRANSAC_ PROVIDER
S_Customer	T_provider
S_Product	T_provider
S_Basket	T_provider
S_Order	T_provider

Table 17 follows the definition of a SCOL_ASPECT_USE table (defined in Table 5) to associate service modules (provided by Table 16) with aspects (provided by Table 13).

Table 17. Example SCOL_ASPECT_USE Table

SVC_MODULE_NAME*	ASPECT_NAME*
S_Customer	A_Customer
S_Customer	A_Address
S_Product	A_Product
S_Basket	A_Basket
S_Basket	A_Position
S_Order	A_OrderHeader
S_Order	A_Position

Table 18 follows the definition of a SCOL_QUERY table (defined in Table 6) to define queries designed to facilitate business process **150** of FIG. 5. For example, QueryByName query associated with S_Customer service module takes a Customer_Stucture as input for the query and a set of customer keys (Customer_Key) that defines which keys may be used for filtering. Field PROVIDER_CLASS specifies which query service provider **32** (referring to FIG. 3) is associated with each service module. In Table 18, query service provider Q_provider (e.g., **32**) is associated with each service module.

Table 18. Example SCOL_QUERY Table

SVC_MODULE_NAME*	QUERY_NAME*	RESULT_ASPECT	PARAM_STRUCTURE	INPUT_KEY_ASPECT	PROVIDER_CLASS
S_Customer	QueryByName	Customer_Key	Customer_Structure	Customer_Key	Q_provider
S_Product	QueryByName	Product_Key	Product_Structure	Product_Key	Q_provider
S_Basket	QueryByCustomer	Basket_Key	Customer_Key_Table	Customer_Key	Q_provider
S_OrderHeader	QueryByCustomer	OrderHeader Key	Customer_Key_Table	Customer_Key	Q_provider

Table 19 defines a data dictionary for the implementation of repository **18** defined in Tables 13-18. Each row defines a structure having a name and multiple data entries and their types. For example, structure Customer_Structure has one data entry titled "NAME" with a CHAR type indicating a character string. The Customer_Key_Table structure defines a CustomerId key for each customer and also has a CHAR type.

Table 19. Example SCOL_STRUCT Table

STRUCT_NAME*	DATA1	TYPE1	DATA2	TYPE2
Customer_Structure	NAME	CHAR		
Customer_Key_Table	CustomerId	CHAR		
Address_Structure	Town	CHAR	Street	CHAR
Address_Key_Table	AddressId	CHAR		
Product_Structure	Name	CHAR	ProductId	CHAR
Product_Key_Table	ProductId	CHAR		
Basket_Structure				
Basket_Key_Table	BasketId	CHAR		
Position_Structure				
Position_Key_Table	PositionId	CHAR		
OrderHeader_Structure	Submitted	CHAR		
OrderHeader_Key_Table	OrderId	CHAR		

The database operations described above for process **150** are defined in this implementation of repository **18** as follows. Querying (**154**), included in process **150**, of the Customers database table (Table 7) is described in meta data repository **18** by the QueryByName query associated with aspect service module S_Customer in Table 18. This QueryByName query associated with aspect service module S_Customer is selected

because the front end application program **12** has obtained a customer name and service module S_Customer contains aspects with customer names. For example, front end application program **12** can submit query QueryByName associated with service module S_Customer with NAME = "John Smith" and no filtering Customer_Key specified to service manager **16**. Service manager **16** checks repository **18** to ensure that the query is defined. Service manager **16** then submits the query to Q_provider (e.g., **32**) that queries the Customer database table (Table 7) in database **24** and the output is sent back to front end application program **12** is a record set containing CustomerId = {1}.

Inserting (**160**), included in process **150**, on Customers Addresses database table (Table 8) and inserting (**162**), included in process **150**, on Customers database table (Table 7) are described by standard Insert operations (described previously) on aspects A_Address and A_Customer, respectively, in the meta data repository **18**.

Querying (**166**), included in process **150**, on the Products database table (Table 9) for a product name is described by QueryByName query associated with service module S_Product defined in Table 18. For example, application **12** can submit the query QueryByName associated with service module S_Product with Name = "Wrench" and no filtering Product_Key specified to service manager **16**. Service manager **16** checks repository **18** to ensure that the query is defined. Service manager **16** then submits the query to Q_provider (e.g., **32**) queries database **24** and the output sent back to application **12** is a record set containing ProductId = {3}.

Inserting (**170, 172,** and **174**), included in process **150**, are defined by insert operations on aspects A_OrderHeader, A_Basket, and A_Position, respectively.

Querying (**178**), included in process **150**, Orders database table (Table 12) by customer is described by the QueryByCustomer query associated with service module S_Order defined in Table 18. For example, front end application program **12** can submit query QueryByCustomer associated with service module S_Order with Customer_Key (CustomerId) = {2} and no filtering OrderHeader_Key. Service manager **16** checks repository **18** to ensure that the query is defined. Service manager **16** then submits the query to Q_provider (e.g., **32**) that queries database **24** and the output is sent back to application **12** is a record set containing OrderHeader_Key (OrderId) = {2, 3}.

Selecting (180), included in process 150, order operation on Orders database table (Table 12) and setting (182) submitted field to true on selected orders are defined by the Execute Submit action (defined in Table 14) on aspect A_OrderHeader in repository 18. For example, front end application program 12 sends the Submit action on aspect A_OrderHeader to service manager 16 with OrderHeader_Key = {2, 3}. Service manager 16 then sends the submit operation to S_provider (e.g., 34) that changes the Submitted field in Orders database table (Table 12) to "True" for selected rows corresponding to OrderId = {2, 3}.

Getting (184) customer address, included in process 150, from Addresses database table (Table 8) is defined by the standard Select By Relation action on A_Customer aspect. For example, the front end application program 12 sends a Select By Relation action on A_Customer aspect specifying relation R_Customer_To_Address and Customer_Key = {2} to service manager 16. Service manager 16 checks the request against repository 18 and passes the request to service provider S_provider (e.g., 34) that looks up foreign key AddressId matching CustomerId = {2} and navigates to Addresses table 8. S_provider (e.g., 34) returns a record set containing {Louisville, Willow Avenue} from Addresses database table (Table 8) to application 12 via service manager 16.

The techniques described above can be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. The techniques also can be implemented as a computer program product, i.e., a computer program tangibly embodied in an information carrier, e.g., in a machine-readable storage device or in a propagated signal, for execution by, or to control the operation of, data processing apparatus, e.g., a programmable processor, a computer, or multiple computers. A computer program can be written in any form of programming language, including compiled or interpreted languages, and it can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment. A computer program can be deployed to be executed on one computer or on multiple computers at one site or distributed across multiple sites and interconnected by a communication network.

Method steps of the techniques can be performed by one or more programmable processors executing a computer program to perform functions of the invention by operating on input data and generating output. Method steps can also be performed by, and apparatus of the invention can be implemented as, special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application-specific integrated circuit). The method steps may also be performed in other orders than those described above.

Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and any one or more processors of any kind of digital computer. Generally, a processor will receive instructions and data from a read-only memory or a random access memory or both. The essential elements of a computer are a processor for executing instructions and one or more memory devices for storing instructions and data. Generally, a computer will also include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto-optical disks, or optical disks. Information carriers suitable for embodying computer program instructions and data include all forms of non-volatile memory, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks. The processor and the memory can be supplemented by, or incorporated in special purpose logic circuitry.

The techniques can be implemented using a computing system that includes a back-end component, e.g., as a data server, or that includes a middleware component, e.g., an application server, or that includes a front-end component, e.g., a client computer having a graphical user interface or a Web browser through which a user can interact with an implementation of the techniques, or any combination of such back-end, middleware, or front-end components.

The invention has been described in terms of particular embodiments. Other embodiments are within the scope of the following claims.

What is claimed is:

Claims

1. A computer program product, tangibly embodied in an information carrier, for using a meta model for an enterprise service architecture, the computer program product being operable to cause data processing apparatus to interact with data conforming to a data model, the data model comprising:

a first class to represent data organization in a back end data store, the first class including a data type identifier attribute to permit meta data to identify a data type;

a second class associated with the first class, the second class including a field identifier attribute to permit meta data to identify fields for a particular data type;

a third class associated with the first class, the third class including an action identifier attribute to permit meta data to identify an action; and

a service provider identifier to permit meta data to identify a service provider class that can effect the action.

2. The computer program product of claim 1, wherein the first class further comprises an association to a fourth class representing a structure of fields included in the particular data type.

3. The computer program product of claim 1, wherein the data model further comprises a fourth class representing a service module that combines a group of data types.

4. The computer program product of claim 2 or 3, wherein the data model further comprises a fifth class associated with the fourth class, the fifth class including a query identifier attribute to permit meta data to identify a query associated with the service module.

5. The computer program product of anyone of the preceding claims, wherein the first class further comprises a key identifier to represent a key for the data type.

6. A computer program product, tangibly embodied in an information carrier, for us-

ing a meta model for an enterprise service architecture, the computer program product being operable to cause data processing apparatus to interact with data conforming to a data model, the data model comprising:

an aspect class including a key identifier, the aspect class representing data types in a back end data store;

a structure class associated with the aspect class, the structure class representing structures included in the data types of the aspect class, the structure class including an aggregation of a field class;

an aspect action class associated with the aspect class, the aspect action class representing actions associated with the data types of the aspect class; and

a relation class associated with the aspect class, the relation class representing a relation between instances of the aspect class.

7. The computer program product of claim 6, wherein the aspect class has an association to a service provider class.

8. The computer program product of claim 6 or 7, wherein the data model further comprises a service module class associated with the aspect class.

9. The computer program product of claim 8, wherein the data model further comprises a query class associated with the service module class.

10. The computer program product of claim 9, wherein the association between the query class and the service module class is an aggregation.

11. The computer program product of anyone of claims 6 to 10, wherein the association between the aspect class and the relation class is an aggregation.

12. The computer program product of claim 11, wherein the aggregation is by a source aspect.

13. The computer program product of anyone of claims 6 to 12, wherein the association between the aspect class and the aspect action class is an aggregation.

14. A method for storing meta data conforming to a meta model in a repository used by an enterprise service architecture, the method comprising:

defining a first meta data element associated with an aspect class representing a data type in a back end data store;

defining a second meta data element associated with a field class representing an attribute of the data type in the back end data store;

defining a third meta data element associated with an action class representing an action associated with the data type in the back end data store;

defining an identifier identifying a service provider class to effect the action defined by the third meta data element; and

storing the meta data elements and the identifier in the repository.

15. The method of claim 14, further comprising verifying the first, second, and third meta data elements conform to the aspect class, the field class, and the action class, respectively.

16. The method of claim 14 or 15, further comprising querying the repository to access the meta data elements to determine organization of data in the back end data store.

17. A system for using a meta model for an enterprise service architecture, the system comprising a repository including data conforming to a data model, the data model comprising:

an aspect class including a key identifier, the aspect class representing data types in a back end data store;

a structure class associated with the aspect class, the structure class representing structures included in the data types of the aspect class, the structure class including an aggregation of a field class;

an aspect action class associated with the aspect class, the aspect action class representing actions associated with the data types of the aspect class; and

a relation class associated with the aspect class, the relation class representing a relation between instances of the aspect class.

18. The system of claim 17, wherein the aspect class has an association to a service provider class.

19. The system of claim 17 or 18, wherein the data model further comprises a service module class associated with the aspect class.

20. The system of claim 19, wherein the data model further comprises a query class associated with the service module class.

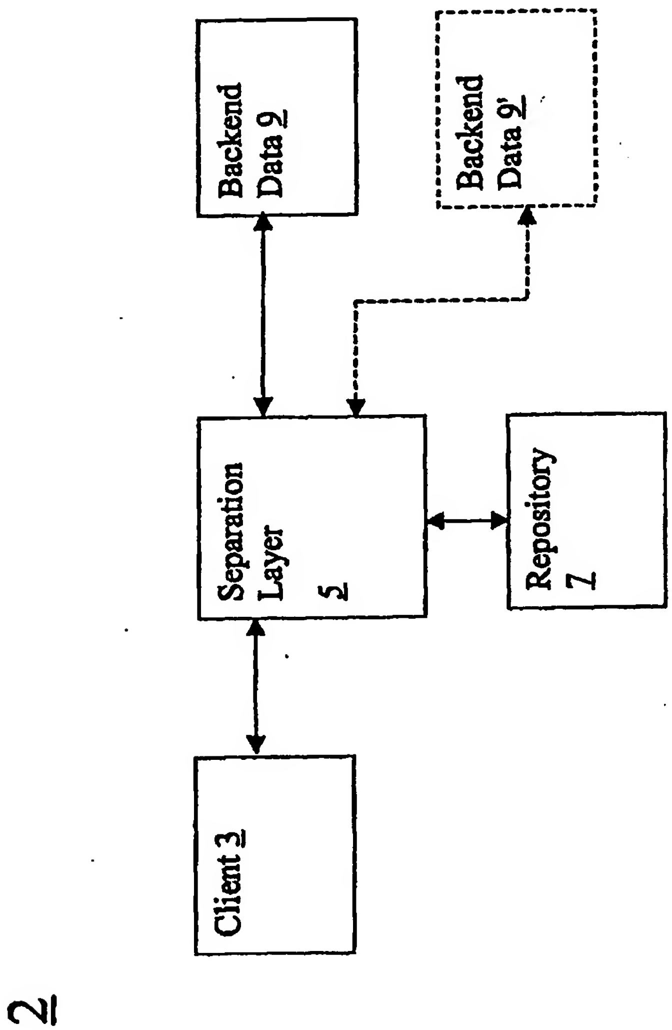

Backend Data 9
Backend Data 9'
Separation Layer 5
Repository 7
Client 3
2

FIG. 1

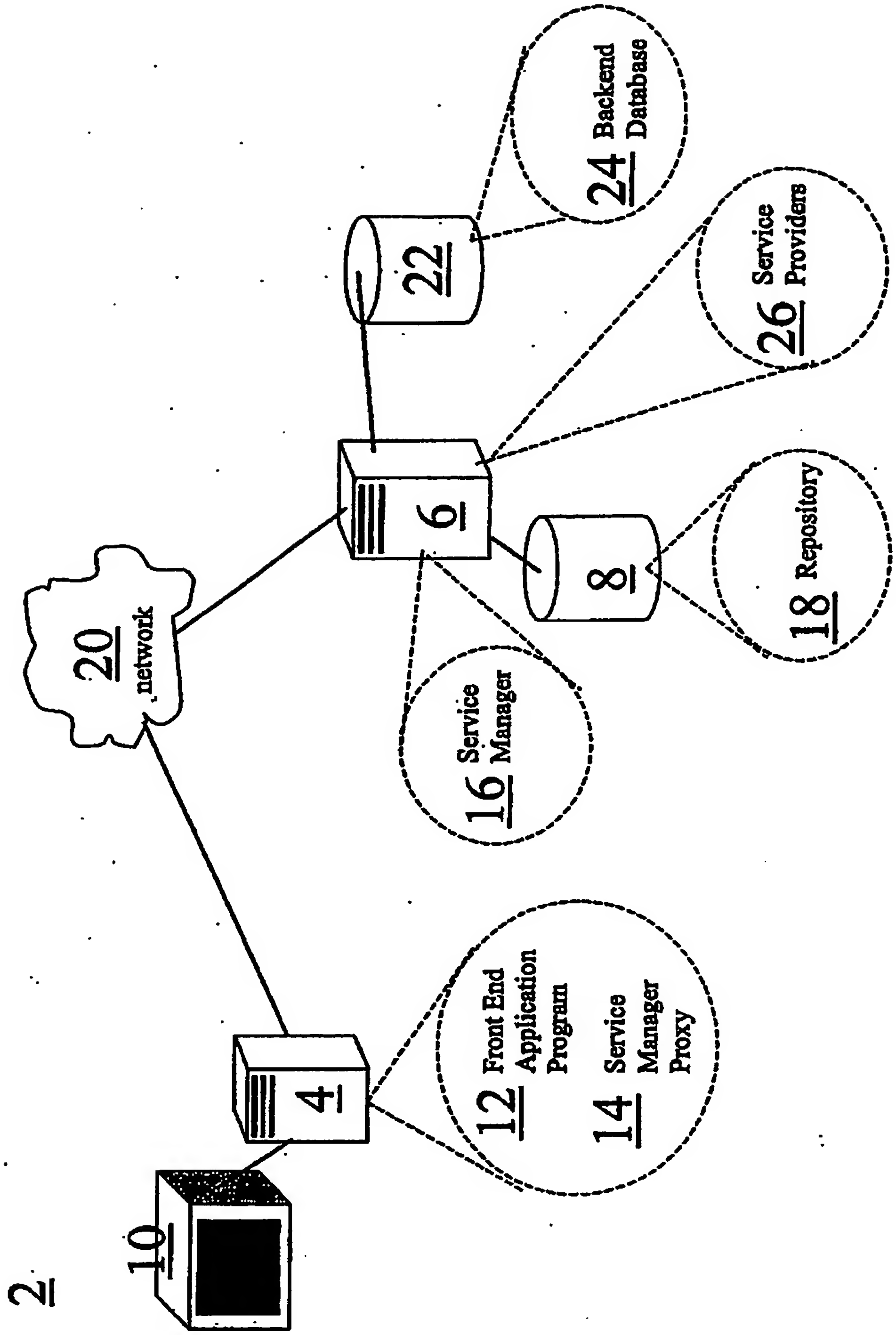

2
10
4
12 Front End Application Program
14 Service Manager Proxy
20 network
6
16 Service Manager
8
18 Repository
22
24 Backend Database
26 Service Providers

FIG. 2

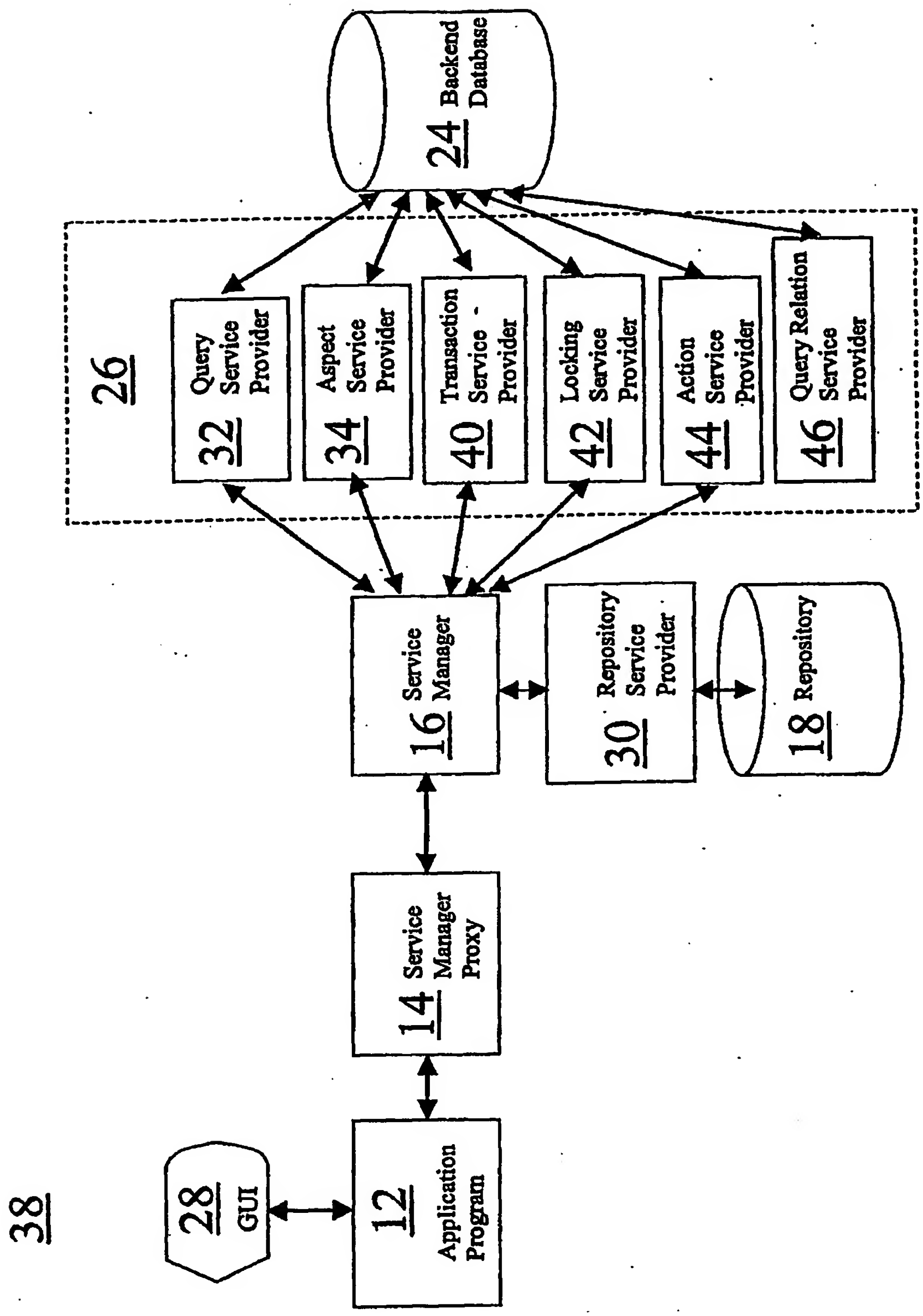
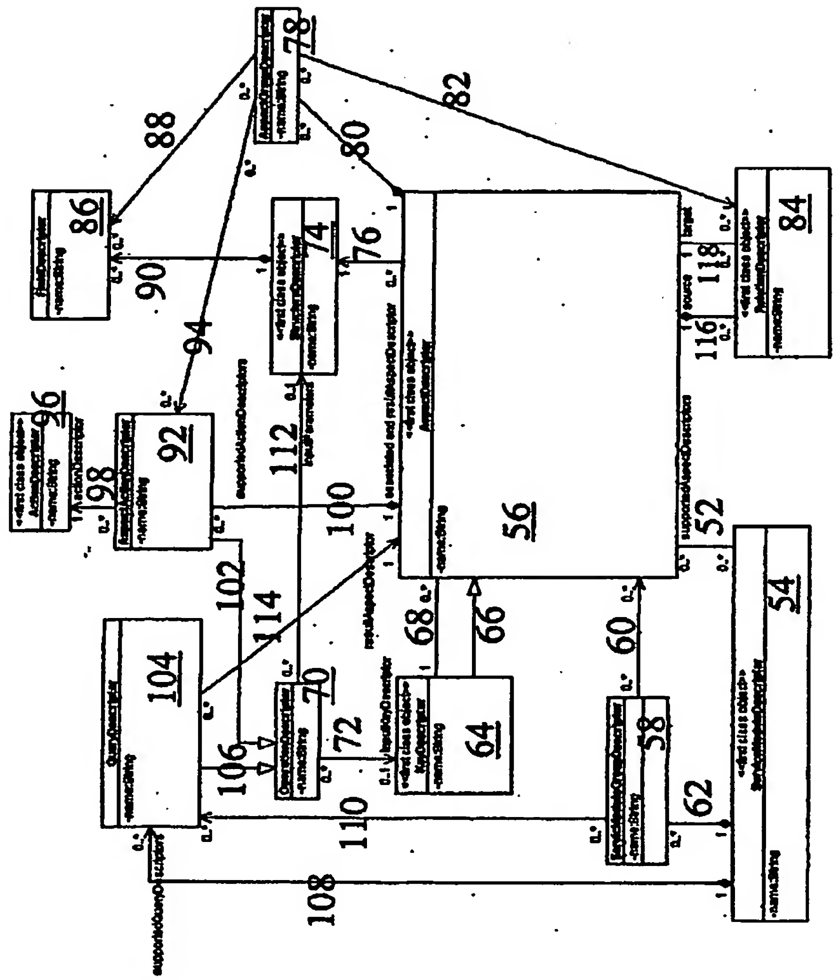

38
28 GUI
12 Application Program
14 Service Manager Proxy
16 Service Manager
30 Repository Service Provider
18 Repository
26
32 Query Service Provider
34 Aspect Service Provider
40 Transaction Service - Provider
42 Locking Service Provider
44 Action Service Provider
46 Query Relation Service Provider
24 Backend Database

FIG. 3


78
88
80
82
86
74
76
84
90
94
118
116
96
92
112
100
56
52
102
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104
68
66
60
70
72
64
58
106
62
110
54
108

FIG. 4

50

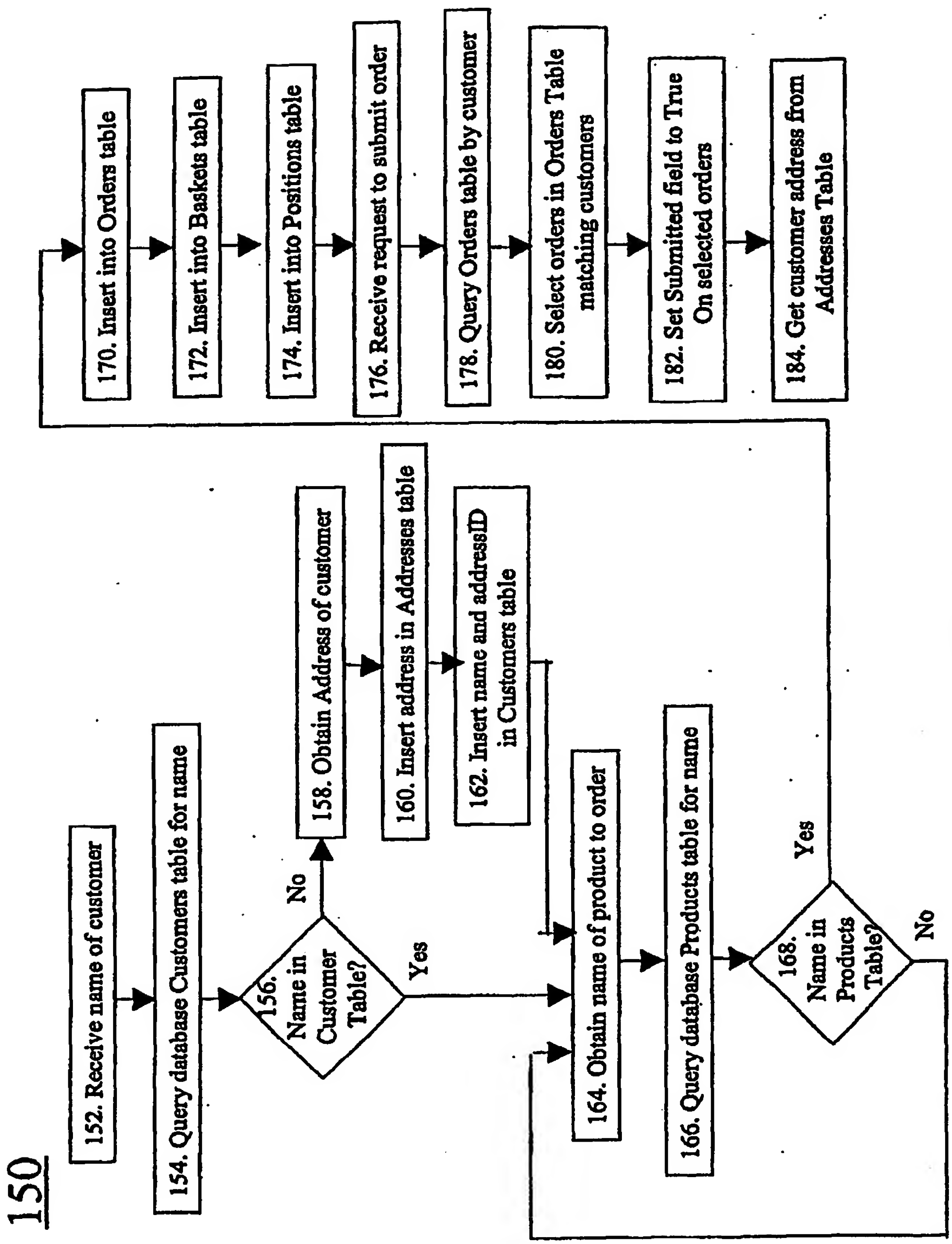
150
152. Receive name of customer
154. Query database Customers table for name
156. Name in Customer Table?
No
Yes
158. Obtain Address of customer
160. Insert address in Addresses table
162. Insert name and addressID in Customers table
164. Obtain name of product to order
166. Query database Products table for name
168. Name in Products Table?
Yes
No
170. Insert into Orders table
172. Insert into Baskets table
174. Insert into Positions table
176. Receive request to submit order
178. Query Orders table by customer
180. Select orders in Orders Table matching customers
182. Set Submitted field to True On selected orders
184. Get customer address from Addresses Table

FIG. 5

200 Relations between Aspects

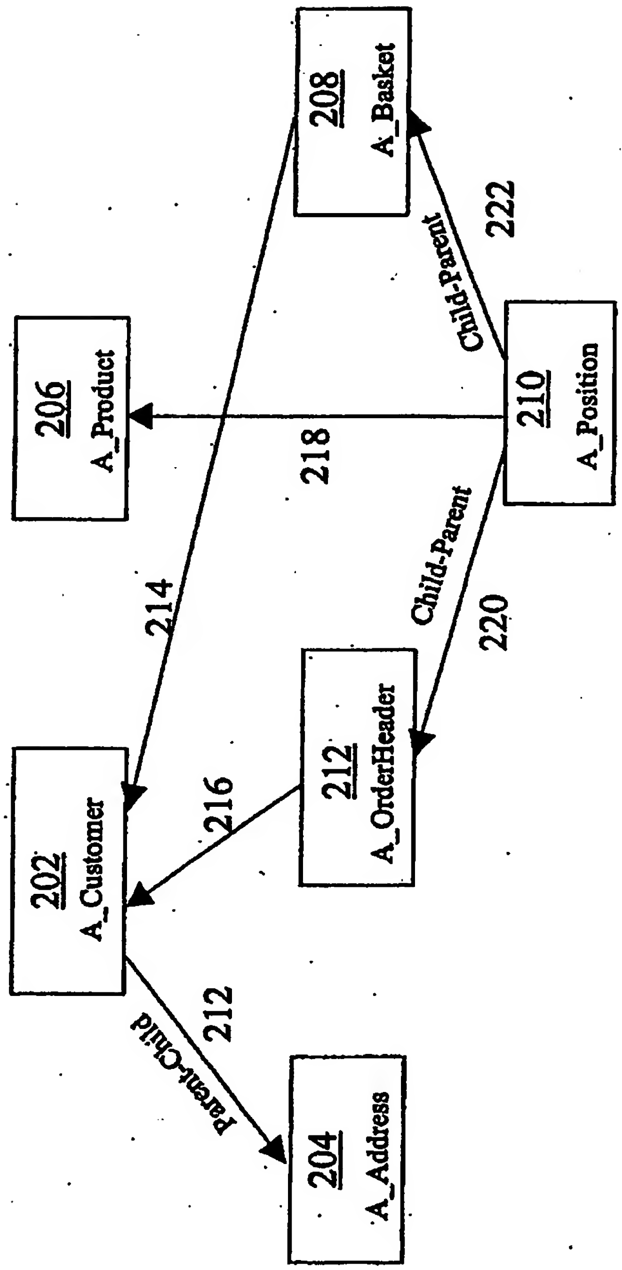

FIG. 6